

# **FINAL EVALUATION REPORT**

## **MATHEMATICS: MODELING OUR WORLD (MMOW)**

A Product of COMAP, Bedford, MA

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## **BACKGROUND / PURPOSE**

In the fall of 1999, Learning Innovations at WestEd was asked to undertake an extensive evaluation of COMAP's *Mathematics: Modeling Our World (MMOW)*, an integrated mathematics high school textbook series that provides opportunities for students to engage in in-depth mathematics problem-solving using extensive real-world scenarios. The MMOW series was piloted in early years in a number of settings and COMAP provides or collaborates with others to provide intensive professional training experiences for teachers using the series.

The broad purposes of this evaluation work are to:

- Provide implementation, effectiveness, and impact data concerning MMOW that COMAP can use with key audiences such as potential clients and organizations that recommend textbooks to such clients;
- Provide useful formative evaluation data to COMAP that informs them in ways that help them provide more effective training and support services for teachers and districts using MMOW;
- Promote reflection on practice of participating teachers and potentially increase their support for continued or increased use of MMOW; and
- Establish key relationships and understandings with user schools and districts concerning student score data available currently and in future years, so that a solid set of baseline and follow-up data can be gathered, analyzed, and effectively presented over time.

## SELECTED EVALUATION QUESTIONS

The following are a sampling of evaluation questions addressed in this study from the data collection methods used:

### ***Teacher Training and Support***

- To what extent and in what ways
  - Have participating teachers found the MMOW training and support useful and effective?
  - Have they found that the training and support helped them make the kinds of changes in practice needed to fully implement MMOW?
  - Have they had opportunities to maintain contact with other teachers using MMOW in ways that support them in the changes in classroom practice they choose to make using MMOW?
- What improvements in training and support would they suggest for future implementing teachers? What additional training or support would be most helpful to them in the future?

### ***Implementation of MMOW in the Classroom***

How do participating teachers describe:

- The extent and ways in which they have implemented MMOW in their classroom teaching?
- The different aspects of MMOW materials and approaches that they find most useful and effective with their students?
- The changes in their classroom practices that have occurred through use of MMOW?
- The greatest challenges that they have faced in implementing MMOW, e.g., student engagement, acceptance and understanding by parents, acceptance and understanding by other teachers?
- Support they have received from school and district administration?
- Strategies they would suggest to broaden the use of MMOW in their own school or district setting?

### ***Impact of MMOW on Students***

- Changes they are seeing in their students in terms of:
  - problem-solving strategies used,
  - understanding of mathematics concepts,
  - confidence in their ability to use mathematics,
  - attitudes toward the value of mathematics in the world beyond the classroom,
  - intention to continue their studies in mathematics?
- Suggested revisions to the current MMOW text?

### **Student Achievement**

- What differences emerge between MMOW students and comparable students in their settings on traditional measures of achievement such as PSAT, SAT, and statewide testing? Are these differences variable according to specific educational settings or among certain groups of students?
- How do MMOW students achieve on standardized tests that closely mirror NCTM standards?

## **METHODS**

The following data collection activities were used in preparation for this report. These activities spanned from January, 2000 through March, 2001.

***In-Depth Telephone Interviews of Teachers*** – Using the list of MMOW users gleaned from book sales data, six classroom teachers were selected to participate in in-depth telephone interviews concerning their experience with COMAP’s training program, their use of the textbook, implementation of the program with students, changes in classroom practices, and impact on student learning and attitudes. A purposive sampling technique was used in selection of teachers to be interviewed, with the selection of a variety of schools:

- Some where the MMOW text was the only mathematics program and schools where students and parents had a choice of traditional math or MMOW;
- A mix of urban and suburban schools; and
- A mix of teachers who were both new at using the MMOW text and teachers who were originally part of the pilot program.

***Case Study Site Visit*** – North St. Paul, Minnesota. A site visit was conducted to one MMOW implementation school—a large, comprehensive high school in a middle class suburban setting. The site visit included:

- An interview with the district coordinator concerning district efforts to support use of MMOW as well as available student math achievement data and resulting analyses;
- Interviews of teachers using MMOW; and
- Classroom observations and informal interviews of students.

***Case Study Site Visit*** – District 2 in New York City. A site visit was conducted to two of the four small high schools in the district, all of which have implemented MMOW for all students, beginning with the class of 2003. Pilot implementation had occurred with some classes in the year before. The site visit and follow-up telephone interviews included:

- Visits to two of the four high schools in the district
- Interview with district secondary mathematics coordinator
  - In person interviews with five teachers (out of the 10 teachers teaching MMOW in the district)
  - Three classroom observations

- Informal small group interviews with approximately 20 students in two classes
- Follow-up telephone interviews with two additional teachers and the district staff developer who supports the MMOW teachers

***Gathering, Analysis, and Presentation of Student Achievement Data –***

- Telephone contact with appropriate school and district personnel to:
  - discuss student score data availability and previous analyses made;
  - discuss the benefits of proposed analyses to be made through the MMOW evaluation study;
  - negotiate evaluation data to be provided to the MMOW evaluation project; and
  - establish plans for future data to be gathered or provided.

## **RESULTS: In-Depth Teacher Telephone Interviews**

All teachers selected for interviews were experienced teachers, with teaching experience ranging from seven to 30 years. Three of the teachers were fairly new to the MMOW text, having taught using the text only one or two years. Two teachers in the sample had been using the MMOW texts for four and six years respectively. The findings of the interviews, conducted between March and June, 2000, are presented below under the general headings of teacher training, implementation of MMOW in the classroom, changes in classroom practice, use of assessment strategies, impact on students, and suggestions for improvement of the textbook.

### ***Teacher Training***

All of the respondents except for one had received training in the use of MMOW texts. All teachers agreed that it was helpful. One teacher who had been involved in the pilot training program very much valued the original training which consisted of an introduction to the context in the book, with an overview of each unit. It had been a week-long workshop taught by the writers themselves which gave the participants a good sense of the philosophy behind the program. For other teachers the training ranged from two weeks in the summer to a one-week intensive training. One teacher described the training as a one-week summer institute for two summers with the addition of several Saturday morning workshops throughout the year.

Generally, the teachers felt that the training was useful and effective, giving them the background in the theory behind the text and helping build confidence in the teachers to try this different approach. Suggestions were made to allow more time for groups to spend time together planning their year.

**“It [the training] showed us the pitfalls that students could have. It made me more comfortable with the fact that they’d be moving around and there’d be noise.”**                    **--teacher**

Staying in touch throughout the year either through e-mail or once a month for a meeting or an occasional Saturday morning workshop proved to be important to the teachers and gave them added support for the program. One teacher described his participation in a two week intensive training in the summer of 1998 where, in his words, they went “unit by unit and learned how to deal with each case.” The follow up to the summer training for him was a “great safety net.”

### ***Implementation of MMOW in the Classroom***

Teachers described their implementation of the program in two ways. They either went unit by unit sequentially or they were very selective about the units they covered, realizing that they were not going to get to all of them. Curriculum coverage was an issue for many teachers interviewed, with the challenge often mentioned of staying focused and on track and not spending too much time on any one unit.

**“Prep time for me requires lots of reading ahead and working on my presentation. I underestimated how long some activities take for students to make connections.” --teacher**

All teachers liked having their students work in groups, the fact that technology was embedded in the text, and that assessments were provided. All of the teachers mentioned the value of the simulations. One teacher mentioned the challenge of increased preparation time involved with this program.

### ***Changes in Classroom Practice***

All teachers reported that they had made changes in their teaching as a result of their use of the MMOW textbook. One reported that he is using more open-ended questions and “allowing students to discover” and that this new technique is being carried over into his traditional classes. Others mentioned less lecturing and more time for students to work on

**“I no longer lecture. I allow students to come to their learning on their own. I’m the safety net. It’s been a 180 degree change. I trust the students.” --teacher**

and become more aware of their own thought processes. One teacher, who was not used to being bound to a textbook and described herself as a constructivist, found it difficult to teach using problems that she hadn’t written herself.

### ***Use of Assessment Strategies***

Regarding the use of the assessment strategies provided in the textbook, all of the teachers interviewed made adjustments to the assessment problems. Many teachers used them for review and supplemented them with their own assessments.

### ***Impact on Students***

All the teachers interviewed reported an impact on student learning. They noted improvement in problem solving as well as understanding of mathematics concepts.

**solving strategies] even with lower level students. They no longer say 'I don't know how to do it.' They at least make an attempt. They don't close their book."**

**--teacher**

**"They understand more than algorithms, not as deep as I'd like but greater than traditional."**

**--teacher**

Teachers interviewed also mentioned improved confidence and attitudes toward the value of mathematics in the world beyond the classroom and their intentions to continue their studies in math.

**"Some [changes in attitude], mostly enjoying, more activity, more to do. For kids who do well in a traditional scheme they have more frustration. They are challenged early on and my attitude is that they will get a better background."**

**--**

**teacher**

**"More confidence. In fact, they thought the SATs had MMOW problems on it."**

**--teacher**

**"Sophomores plan to take Integrated 3. Juniors may. The low level kids have more exposure to high level math. The smarter kids are geared up for calculus. This exposure and the topics show them that high level math isn't just numbers."**

**--teacher**

### ***District and Parent Support***

In terms of the support received from the school district administration and parents, there was a range of responses. One teacher who taught in an urban district indicated no district support, while another teacher from a different urban district described her district as very supportive.

Several of the teachers spoke about the importance of working with parents to get their support, indicating that building support takes time and continuous communication. One concern raised by parents is that it is hard for parents and/or tutors to help the students with their homework given that they don't always understand the problems.

**They [the district] provided substitute teachers and ongoing training, bought textbooks and calculators and provided moral support.” --teacher**

**“The administration gave us a great deal of support to implement and publicize the program two years ago. Parents were skeptical. We talked about it at the parent conferences and open house during the year. We showed parents the literature and how they could help. When they understood it they were really supportive and said, ‘I wish there was something like this when I was around.’” --teacher**

## **RESULTS: Site Visit to North High School, North St. Paul, Minnesota**

**DATA COLLECTION ACTIVITIES:** In June, 2000, an in-depth site visit was conducted at North High School in North St. Paul, Minnesota. Data collection activities included individual and group interviews with six teachers (most with over 10 years teaching experience, and one second year teacher), observation of two classes (including informal interviews with students), and an interview with the district curriculum director.

**BACKGROUND / SETTING:** North St. Paul is a suburban community with students primarily from middle and lower-middle class environments. The 1999-2000 school year was the second year of broad use of MMOW in the district. Full adaptation of the text occurred in the spring of 1998. In October, 1997, as Minnesota was about to pass the profile of learning (statewide standards) it became clear that all students would need to be able to meet the requirements of three standards that significantly raised the bar for mathematics achievement of all students in the state. At a lengthy, district-wide meeting of mathematics teachers, it was decided that all high school students would have to complete mathematics work through pre-calculus. There was virtual consensus at that time to structurally change the math program in the district. Both district high schools (North High School being one of these) accepted the plan for an integrated mathematics program. During the months of October through December, meetings were held to discuss these plans with parents from the district. Parents voted in agreement in December of that year. During the months of January through March of 1998, teachers and the curriculum director examined a number of different integrated math programs. Consensus was gained among staff and parents to adapt MMOW.

At North High School, the top 10% of the students were traditionally placed in accelerated coursework, however the remaining students were grouped heterogeneously. The school day is organized into four extended class periods. All students are now required to take Integrated Math 1, 2, and half a year of the third level. Students then move into pre-calculus. Ninth graders in 1999-2000 were still separated into traditional math courses because of the sequence of courses in which they had already participated. Teachers received extensive training in content and pedagogy using the MMOW textbook, primarily through a grant and provided through the a project associated with the Sci-Math organization in Minnesota.

### **FINDINGS: Teacher Interviews**

**Training and Support** – The teachers interviewed indicated that the training they received before implementation of MMOW focused a great deal both on content and the approach of the book. They mentioned how the instructor effectively modeled the open questioning techniques needed for this type of approach and engaged the teachers in the same sort of problem-solving that their students would be doing.

One teacher pointed out that the training helped teachers focus on what was important in this new approach to teaching mathematics. Several mentioned that it would have been nearly impossible to use the MMOW text without corresponding training. They

**“We learned the great importance of finding the right balance of giving enough information to the learner, but not too much.”**  
--teacher

also spoke about how helpful it was that members of their department had written numerous lesson plans to go with the text which were extremely helpful. One teacher made special note of the usefulness of the CD Rom that accompanied the text, providing data sets and practical exams.

**“We focused on problem-solving, got into the approach of the book. I loved working at the problem-solving and the math concepts at the same time.”** --teacher

***MMOW Implementation / Change in Classroom Practice*** – All the teachers interviewed at North High School indicated changes in their classroom practice since implementing MMOW. Some veteran teachers who had taught traditional algebra and geometry courses found it particularly challenging because of the pedagogical changes needed.

Some of the changes in their classroom practice that teachers noted included:

- More small group work;
- More thinking and problem-solving;
- Less spoon-feeding of information to students;
- Less lecturing to the whole class and more probing with small groups or individuals;
- More actual discussion of math;
- Less repetition of procedures, problems; and
- More constructivist approach to learning.

**“The first year was so hard—a new way. There was no pedagogy to fall back on. I was used to doing it the old way. The book leads us, but sometimes I don’t know where we’re going.”**

--teacher

**“The biggest change in my classroom is the better overall class discussion because of the deep context of the problems.”** --teacher

Teachers spoke of the problem-solving as a major shift in practice and one that they and the students enjoyed. However, almost every teacher and many students mentioned that the difficult language, especially in the Year 1 book, sometimes got in the way of effective problem-solving.

**“This approach makes sense. We look at the problem and figure the math that’s needed rather than the reverse. It’s more like the way people think.”** --teacher

One teacher described how student homework had changed since use of MMOW. Homework assignments, rather than consisting of practice of what was presented in class, included new problems requiring different approaches. It

**“I let my students vent when they struggle with a problem. I tell them that they’ll remember better and understand better if they figure things out for themselves ”** --teacher

was also mentioned that discussions of homework questions the next day were often much more substantive and interesting because of the contextual nature of the assignments. Several teachers mentioned as well the importance of letting the students vent when they have to struggle with homework or classroom problems.

**Impact of MMOW on Students** – The teachers interviewed at this high school had no difficulty describing the impacts they see on their students since using the MMOW textbook and approach. Some of these changes included:

- Many students like math more, although there are still those who do not. Some students indicate greater frustration, while others understand and enjoy math more than ever before.
- Students get deeply involved in the discussions of problems, making personal connections and giving input. Students who are not necessarily strong in math get very involved in the classroom discussion and may not totally understand the math, but at the same time, are able to contribute to the class learning.
- Students understand what math is used for.
- The biggest challenge for students seems to be reading and interpreting the text, the most common question being: “What am I being asked to do here?”
- Sometimes there is a bigger split academically, in that the lower achieving students give up, e.g., over 20% of the students in grade 9 are not passing. Some of the students who are not passing, however, say that they find math interesting for the first time.
- Some students who found math easy in traditional courses are finding it much more difficult and requiring more work now (not necessarily harder to understand).
- In terms of confidence, it is often the previously high achieving students who lose confidence (according to one teacher, because they knew the skills, but did not understand the concepts). Several teachers mentioned the boost in confidence that occurs with low achieving students when they understand enough to solve the problem at least at some level.
- Students are developing greater ability to solve problems. They are getting better at solving problems in context.

**“I saw a change in confidence this year in Course 2—graphing theory. It turned the class upside down. The bottom students were very successful—visual and conceptual strengths vs. computational and algebraic strengths. Some of these students had had no success before.”**

teacher

- Students are retaining more of their math learning because of the context attached to it.

**to go into different situations (math or otherwise) and solve problems. Every problem is different. The students have the skills to attack them. The key is for students to try. They can't memorize. The only way is to try things."** --teacher

### ***Parents and MMOW***

In the context of math education reform, parents are taking a larger and often obstructive role. Of some note in North St. Paul is the fact that parents were involved in the decision making about the shift to an integrated math approach as well as other changes, prompted especially by the statewide standards students have to meet. The road to change has not, however, always been smooth. For instance, one teacher mentioned the concerns/questions expressed by a number of parents, including:

- Where is the "real" math?
- How will this help high achieving students?
- How will students do on the statewide exams?
- How well prepared will the students be for courses that follow?

The parent concern mentioned most often by teachers was the difficulty parents have in helping their children with their homework. Many indicate that they have no idea where to start. However, teachers also mentioned parents who were originally doubtful about MMOW but changed their minds when they really saw what their children were learning how to do. They were also encouraged when it was explained to them that the book and the work required of students matches up well to Minnesota state standards as well as the standards of the National Council of Teachers of Mathematics (NCTM).

### ***FINDINGS: Classroom Observations and Interviews with Students***

Two classes of 10<sup>th</sup> graders were visited during the site visit. Since the visit was in June, students were reviewing for their final exam. One group was reviewing in small groups, while the other was engaged in a teacher-led discussion with the whole class. The students working in small groups (about 15 students) participated in brief, informal interviews, while the other class was observed only.

The most notable aspect of the teacher-led review session was that as the teacher reviewed the concepts covered on the exam, there was constant reference / connection made to two aspects of the year's work: 1) the context in which the students learned those concepts and 2) the problem-solving approach used when that concept was studied, e.g., use of mirrors or paper-folding. These connections, made constantly, were initiated both by the teacher and by the students. It was notable as well, that as the students and teacher conversed during this class period, the focus was consistently

on problem-solving and there was frequent mention of the existence of multiple ways of finding an answer.

The students interviewed had many positive things to say about their experience with the MMOW program, as well as a few suggestions. The aspects of the program that they appreciated most are illustrated by the comments in the box below:

- **“I like doing big problems in a real scenario with lots of steps. I feel like I’m accomplishing something.”**
- **“I’m more interested in the math because I can use it.”**
- **“It’s easier to remember the math because it’s connected to something.”**
- **“There are more real life situations vs. the old way of skill and drill.”**
- **“This helps us to get it better, understand how it works. You take the math into a real world situation.”**
- **“Math is different. Sometimes it’s fun. Enlightening. A refreshing change from the old drone work.” --students**

***FINDINGS: Student Achievement Data***—One of the likely reasons for the general support of MMOW by parents is that not only were they consulted about the changes being made in curriculum, instruction, and assessment, but that they were promised a frequent and regular accounting of changes in mathematics achievement by the district. The Iowa Tests of Educational Development (ITED) results were used for this purpose. The results of analyses of the ITED have been extremely encouraging and showed significant improvement since implementation of MMOW. See details under section presenting results of student achievement data.

## **RESULTS: SITE VISIT to New York City District 2 High Schools**

***DATA COLLECTION ACTIVITIES:*** In January, 2001, an in-depth site visit was conducted at the Museum School and the Laboratory School (both middle and high school levels) in District 2 in the Manhattan borough of New York City. Data collection activities included individual and group interviews with the district secondary

mathematics coordinator, five teachers (one with many years teaching experience including use of MMOW, and the others relatively new teachers, three using MMOW for the first time); observations of three classroom sessions; and informal interviews with small groups of students in two of the classes. In addition, follow-up telephone interviews were conducted with two teachers at another of the four District 2 high schools as well as the district staff developer who supports the MMOW teachers.

### **BACKGROUND / SETTING:**

District 2 is a large Manhattan school district that supports 16 middle schools and over 30 elementary schools. The four high schools are new to the district over the last 5-10 years and are all relatively small (150-300 students), innovative schools. For example, the students in one of the schools visited, the Museum School, participate in academic programs in the school in the mornings and innovative learning projects at various city museums during the afternoons. One teacher referred to the school as a liberal arts school without a great emphasis on science and mathematics. The two schools that were visited also house middle school grades 6-8.

*Support for Teachers* --The district's secondary mathematics coordinator visits the four schools weekly, observing classes, and providing feedback and coaching to teachers. The district staff developer also meets with the 10 MMOW teachers from the four high schools every other month for continuing training. Earlier training was on a monthly basis. In addition, the staff developer serves as an on-call resource for the MMOW teachers. The teachers visited in the two schools indicated a useful, collegial environment among MMOW teachers.

### **FINDINGS: Teacher Interviews**

**Training and Support** – The teachers interviewed spoke a great deal and positively about the training and support they received from COMAP through the summer institutes and through their own district. They indicated that they valued the development and discussion of lesson plans at the COMAP training and one person indicated a need for more choice of the units they work on during the training.

All the teachers interviewed indicated appreciation as well for the district training and ongoing support they receive. They mentioned the usefulness of teachers planning lessons together and newer teachers hearing the thinking of the teachers who are more experienced with the MMOW approach. Teachers seemed to value the combination of support that they receive through district training and coaching, support from administrators, and collaborative planning and support with other teachers. They recognize that teaching the way that MMOW requires is very hard work and that the support and the small school environment make success possible.

**“I have all the support I need—materials, workshops, everything. Nothing’s missing. I have all the support. But it’s still hard.... When you’re new at something you’re not a specialist, so it’s hard to do.”**  
-- a teacher

**“We [teachers] meet a lot. It’s a small school.”**  
-- a teacher

**MMOW Implementation / Change in Classroom Practice** – Teachers indicated key areas of classroom practice that are central to implementation of MMOW, areas that meant considerable change for many of them:

- Use of cooperative learning on a daily basis
- Less testing
- Less teacher directed learning
- More student exploration and problem-solving
- Students working together after school to do homework

Other initiatives from the district have also been incorporated into the MMOW classrooms. Most notable is the use of “accountable talk” among students. Using this strategy, students from small groups explain their problem-solving approaches to the whole class. Students are responsible/accountable for carrying the discussion and asking probing questions to make sure that other students thoroughly explain how they approached problems.

Teachers noted challenges in keeping the students focused on the critical ideas/concepts, providing timely reinforcement of these critical pieces, and keeping track of the threads of learning through the units.

**Impact of MMOW on Students** – Teachers interviewed were consistent in their positive views of the impact on students of the use of MMOW and the classroom practices that go with it:

- Better understanding of mathematics concepts;
- Better problem-solving strategies;
- More writing about problem-solving;
- Better group and communication skills; and
- Increased confidence in their understanding of concepts and ability to solve complex problems.

Some teachers indicated that the students are required to carry a great deal of responsibility in this program. They indicated as well that students do struggle with the length and difficulty of homework assignments. When asked about how well the MMOW program prepares students for the New York

**“It’s a whole new way of teaching—totally new approach, not traditional. And it’s nice to see almost everyone [students] gets involved....Lots more people are involved. They get the opportunity to talk. Everyone has a voice.”**  
-- a teacher

**“The students write a lot about what they understand. A whole writing section in their binder. They have to explain how we do something, why, and why it makes sense.”** -- a teacher

**“Yes, their [students’] confidence is definitely improved. The first thing we do—lines/equations of lines—they all know how to do it, the formula, that is. But we spend lots of time on the meaning of slope, so now they know what the formula means. After three weeks on it, they actually know what it means. I had a kid say, ‘Whoa, I actually know what this [formula]”**

state Regents examination, teachers expressed concern that they have to provide supplementary work for students. One teacher demonstrated how he correlates for the students what they are learning in MMOW and sample SAT problems.

### ***FINDINGS: Classroom Observations and Interviews with Students***

The student feedback on the MMOW approach and book was once again mixed, and very similar in nature from the reflections of students interviewed in the Minnesota school, including positive comments about the helpfulness of learning math set in a real life context, working in small groups, and learning logical problem-solving approaches, as well as concerns about the difficult reading and homework.

**“I’m learning to think logically—not memorizing equations.”**

**“I can tie math to history. It’s more interesting.”**

**“I get ideas and get help from others in the small group.”**

**“I feel like I’m learning more.... There’s more than one answer.”**

**“It’s the same math, but more challenging.”**

**“It’s less structured. We learn how to make connections.”**

**“It’s easier and harder. It’s not dumbed down, but there’s less pressure.”**

**“More connection to use in real life.”**

**-- students**

### ***FINDINGS: Student Achievement Data***

The full implementation of MMOW across the four high schools in District 2 began only in the 1999-2000 school year with use by all 9<sup>th</sup> graders. These students have not yet taken the Regents exam, although these data will be critical to track over the next few years. The schools, however, do have 10<sup>th</sup> grade PSAT scores for most of these students, and for a group at one school that began MMOW earlier, the 10<sup>th</sup> and 11<sup>th</sup> grade PSAT scores. The two schools visited provided the above data. The data from the other schools was not forthcoming because of school concerns: a) that because of changes in admissions policies each year, that the comparison of cohorts by year would be inappropriate, and b) that parents need to give permission for the student data to be used in this study. Key findings from the preliminary PSAT score analysis are encouraging. For further detail, see results of student achievement data section.

## RESULTS: Student Achievement Data

Over the length of this study, MMOW user schools and districts were contacted by telephone and electronic mail to teachers, school administrators, curriculum directors, and other central administrators to determine:

- to what extent and with which students they are using the textbook;
- measures of student math achievement they have available;
- analyses they may have made of these data; and
- willingness to share their student results and to collaborate in ongoing data analysis studies.

Results indicate a wide variety of uses of the textbook, including:

- some schools using them with high achieving students;
- other schools using them with at-risk or low achieving students;
- some schools using them with the whole school or whole grade cohorts;
- some schools using them with only isolated classes;
- some districts allowing parents to choose between MMOW classes and traditional courses;
- many schools and districts using MMOW for the first year.

Measures of student math achievement are not consistent across sites, and data are not disaggregated by textbook use. Schools and districts that did have some data available reported use of a variety of measures, including:

- Stanford Achievement;
- Iowa Test of Educational Development;
- PSAT, SAT, ACT; and
- Statewide examinations, e.g., New York, Minnesota, Connecticut.

Few of these schools and districts seem to be doing their own analyses such as the ones in North St. Paul to track achievement of students using MMOW.

### ***Improving Achievement Test Scores in North St. Paul, Minnesota***

The use of MMOW is bringing notable improvement in the percent of students who scored in the top quartile (25%) of the Quantitative Thinking component of the Iowa Tests of Educational Development (ITED). See Table 1 below.

**Table 1: Students Who Scored In The Top Quartile (25%) On The Quantitative Thinking Component Of The Iowa Tests Of Educational Development (ITED)**

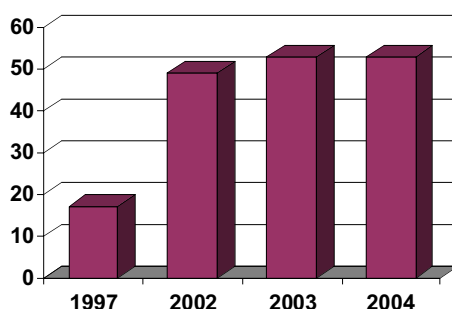
CLASS	GRADE 5*	GRADE 6*	GRADE 7*	GRADE 8*	GRADE 9	GRADE 10	GRADE 11
2002	23%	34%	--	42%	45%	49%	58%
2003	34%	33%	--	--	58%	53%	--
2004	36%	36%	40%	--	53%	--	--**

\* Iowa Tests of Basic Skills (Grades 5-8)

\*\* -- denotes no testing occurred those years

The three classes of students (2002, 2003, and 2004) that have used MMOW exclusively have shown a marked increase in the percent scoring in the top quartile of the ITED quantitative portion. Whereas in the Grade 6 equivalent test (Iowa Test of Basic Skills) only 33% to 36% of these cohorts scored in the top quartile, in Grade 9, 45% to 53% of these classes scored in the top quartile. Almost 60% of the class of 2002 cohort recently scored in the top quartile for this standardized test that is closely linked to NCTM standards.

Before the district began using MMOW, only 17% of the class of 1997 scored in the top quartile of the ITED in the 10<sup>th</sup> grade, as compared to 49% of the class of 2002, 53% of the class of 2003, and 53% of the class of 2004 (9<sup>th</sup> grade scores). See Figure 1 below.



**Figure 1: Percent Of Students Scoring In The Top Quartile (25%) Before MMOW (Class Of 1997) And Since Use Of MMOW (Classes Of 2002 – 2004)**

### ***Improving Achievement Scores in Bald Knob, Arkansas High School***

Means of tenth grade SAT-9 scores from 1998 (pre-MMOW), 1999, and 2000 have been compared to the national mean. The Pre-MMOW mean, although higher than the national mean, was not statistically significantly different. However, the means in 1999 and 2000 (students using MMOW) are significantly higher than the national mean. See Table 2 below.

**Table 2: Comparison of 10<sup>th</sup> Grade SAT-9 Scores Pre-MMOW and With MMOW**

PRE- MMOW 1998 10 <sup>TH</sup> GRADE SCORES	MMOW 1999 10 <sup>TH</sup> GRADE SCORES	MMOW 2000 10 <sup>TH</sup> GRADE SCORES
Class mean = 55	Class mean = 62	Class mean = 60

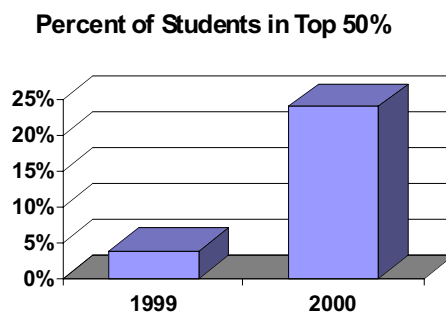
n = 72 National mean = 50  Bald Knob mean IS NOT significantly higher than the national mean of 500	N = 75 National mean = 50  Bald Knob mean IS significantly higher than the national mean of 500 (z=3.05, p≤.01)	n = 80 National mean = 50  Bald Knob mean IS significantly higher than the national mean of 500 (z=2.62, p≤.01)
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A similar success story is taking place in a neighboring Arkansas high school, Mt. Pine High School, all ninth graders take MMOW in heterogeneous groups. They take the Stanford Achievement Test Version 9 in the fall and spring. Ninth graders in the fall of 1998 scored an overall math mean of 7.7. In the spring of 1999 those same students scored 9.4. Those same students scored 9.5 in the following fall.

### ***New York City, District 2 Achievement Scores***

The key findings from the analysis of the PSAT scores compiled from the two schools visited in District 2 are:

- The average PSAT score of the 25 students at the Museum School using MMOW for two years, increased by 32 points. Over these two years, the percent of students in the top two quartiles (top 50%) increased from 4% to 24%. See Figure 2 below



**Figure 2: Percent of MMOW Students scoring in the Top 50% on PSATs**

- At the Laboratory School, the 10<sup>th</sup> grade PSAT scores resulted in 53% of the students in the top two quartiles (top 50%), with 13% in the top quartile. The average score for this cohort, though slightly lower than the national norm, was not statistically significantly lower than the norm ( $t=-1.13$ , 29 d.f.,  $p \leq .05$ ).

## REFLECTIONS / RECOMMENDATIONS

Taking a broad view of this study, there are three areas of significant findings: 1) the consistent and important changes in classroom practice in high school mathematics classrooms using MMOW, 2) the importance of excellent and ongoing training and support for teachers attempting these difficult changes, and 3) the impact on student learning, attitudes, and achievement in mathematics.

***Changes in Classroom Practice in High School Mathematics Classrooms Using MMOW***—Many reform mathematics programs struggle and often find little success in cracking the nut of high school mathematics instructional practice. A textbook alone certainly cannot be expected to accomplish this daunting task. From extensive interviews with practitioners and students and from observations of teachers and students engaged in MMOW work, it is clear that the use of this textbook (which teachers admit they could never use without training), and, of course, the approach that it requires is creating monumental changes in classroom learning environments and processes. Students are taking charge of their learning, their problem-solving, their deep understanding of mathematical concepts, and their probing of complex questions. They are working together with other students to solve these complexities. They are taking on more responsibility for their learning and for explaining what they think.

Their teachers are restraining themselves from telling the students how to solve problems, but rather: 1) guiding them in their inquiry, 2) keeping them focused on essential mathematical concepts, 3) reinforcing these concepts and helping students recognize and organize their learning, 4) helping students relate mathematics and their mathematics learning to real world, complex contextual scenarios, and 5) encouraging students to persist in seeking answers, exploring possibilities, and synthesizing their mathematical understanding.

***The Importance Of Excellent And Ongoing Training And Support For Teachers***—Teacher after teacher noted the importance of the following factors that helped them be successful in changing the way they teach to such an extent:

- Excellent, hands-on training from COMAP that is provided not just once, but year after year, at higher levels;
- Ongoing training and/or coaching from colleagues at the school and classroom level;
- Ongoing collaborative planning, troubleshooting, sharing, and encouragement from colleagues doing the same work;
- Tangible support for and understanding of the instructional changes they are making and the challenges that go with these changes from district and school administrators.

***The Impact On Student Learning, Attitudes, And Achievement In Mathematics***

—From interviews with teachers and with their students, and from observing the two groups in action using MMOW, it is clear that there is considerable positive impact on student learning, student attitudes towards mathematics and their ability to understand and apply mathematics, as well as on standardized achievement scores. These areas of impact include:

- Deeper understanding of critical mathematical concepts, not just calculations;
- Increased ability to approach and solve complex, contextually rich, real world problems;
- Increased skills in collaboratively solving mathematical problems;
- Increased confidence in themselves as mathematicians and problem-solvers;
- Increased interest in and enjoyment of mathematics; and

- Increased, or at least, maintained levels of achievement on standardized tests used by districts and states.

## APPENDIX A: Success Stories

## MATHEMATICS: MODELING OUR WORLD SUCCESS STORY—North St. Paul, MN

### USE OF MMOW BRINGS NOTABLE IMPROVEMENT IN PERCENT OF STUDENTS WHO SCORED IN THE TOP QUARTILE (25%) ON THE QUANTITATIVE THINKING COMPONENT OF THE IOWA TESTS OF EDUCATIONAL DEVELOPMENT (ITED)

CLASS	GRADE 5*	GRADE 6*	GRADE 7*	GRADE 8*	GRADE 9	GRADE 10	GRADE 11
2002	23%	34%	--	42%	45%	49%	58%
2003	34%	33%	--	--	58%	53%	--
2004	36%	36%	40%	--	53%	--	--**

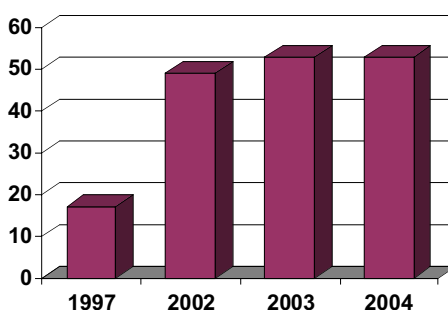
\* Iowa Tests of Basic Skills (Grades 5-8)

\*\* -- denotes no testing occurred those years

The three classes of students (2002, 2003, and 2004) that have used MMOW exclusively have shown a marked increase in the percent scoring in the top quartile of the ITED quantitative portion. Whereas in the Grade 6 equivalent test (Iowa Test of Basic Skills) only 33% to 36% of these cohorts scored in the top quartile, in Grade 9, 45% to 53% of these classes scored in the top quartile. Almost 60% of the class of 2002 cohort recently scored in the top quartile for this standardized test that is closely linked to NCTM standards.

### PERCENT OF STUDENTS SCORING IN THE TOP QUARTILE (25%) BEFORE MMOW (Class of 1997) AND SINCE USE OF MMOW (Classes of 2002 – 2004)

Before the district began using MMOW, only 17% of the class of 1997 scored in the top quartile of the ITED in the 10<sup>th</sup> grade, as compared to 49% of the class of 2002, 53% of the class of 2003, and 53% of the class of 2004 (9<sup>th</sup> grade scores).



## MATHEMATICS: MODELING OUR WORLD SUCCESS STORY—Bald Knob, Arkansas

USE OF MMOW BRINGS STATISTICALLY SIGNIFICANT  
IMPROVEMENT IN CLASS AVERAGE SCORE ON THE SAT-9  
TAKEN IN 10<sup>TH</sup> GRADE

PRE- MMOW 1998 10 <sup>TH</sup> GRADE SCORES	MMOW 1999 10 <sup>TH</sup> GRADE SCORES	MMOW 2000 10 <sup>TH</sup> GRADE SCORES
Class mean = 55 n = 72 National mean = 50  Bald Knob mean <b>IS NOT</b> significantly higher than the national mean of 500	Class mean = 62 n = 75 National mean = 50  Bald Knob mean <b>IS</b> significantly higher than the national mean of 500 (z=3.05, p<.01)	Class mean = 60 n = 80 National mean = 50  Bald Knob mean <b>IS</b> significantly higher than the national mean of 500 (z=2.62, p<.01)

